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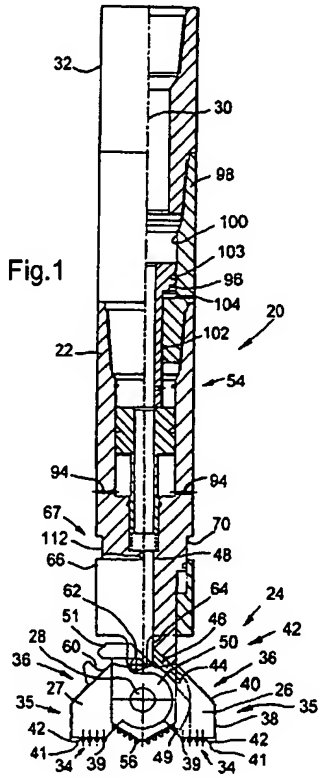
(54) Abstract Title
Expandable Drilling Apparatus

(57) Drilling apparatus 20 has two pivoting blades 26, 27 which are movable between a closed position, in which they cut a bore which clears the body 22 and an open position in which they cut a wider bore. In either configuration, the blades 26, 27 present a part-cylindrical outer gauge-cutting surface. The body 22 features a cutting region 56 at its leading end which cuts the centre of the bore's face when the blades are extended, and is covered by the blades when they are retracted. Actuation is by means of a piston 96 operated by the pressure of the cutting fluid. Additional fluid ports are opened when the blades 26, 27 are deployed, allowing the surface operator to confirm that the blades 26, 27 are hilly extended by monitoring the resultant pressure drop.

Fig.1



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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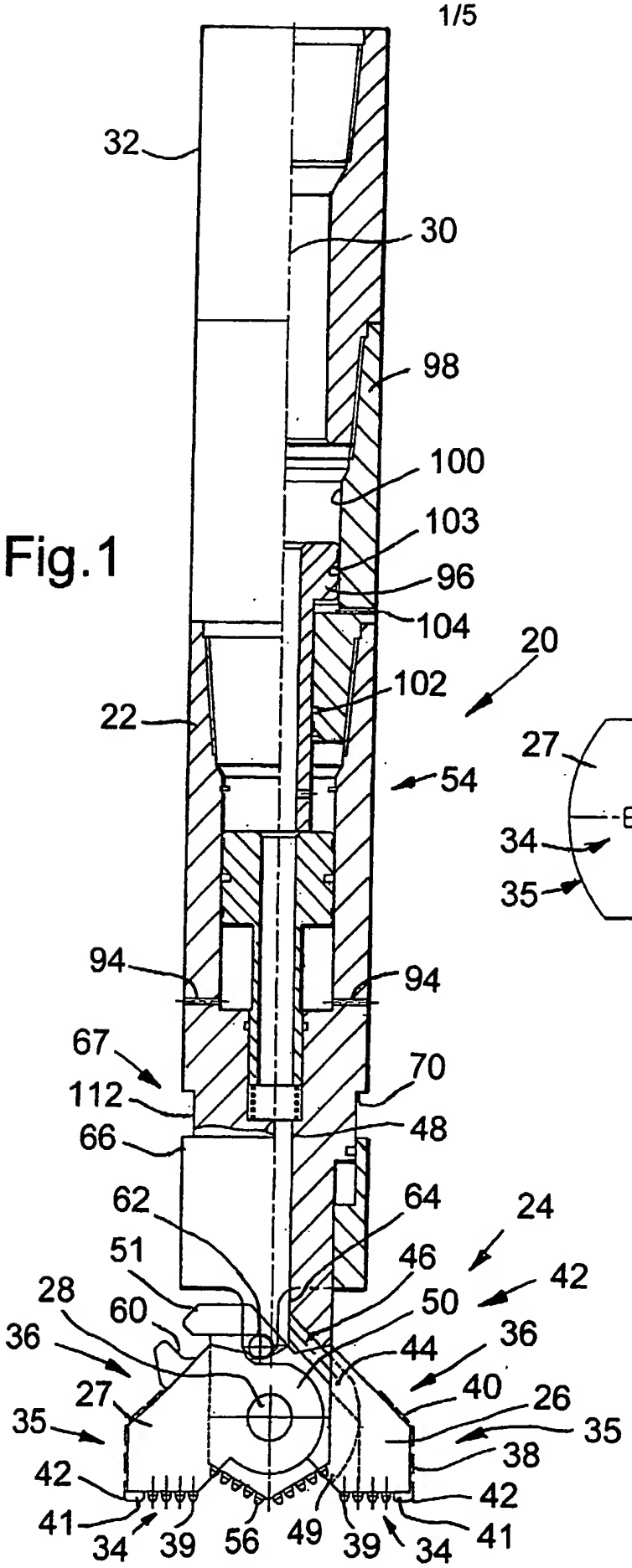
Fig.1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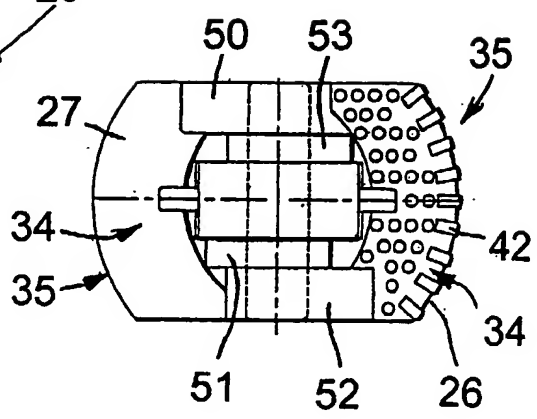
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Fig.2

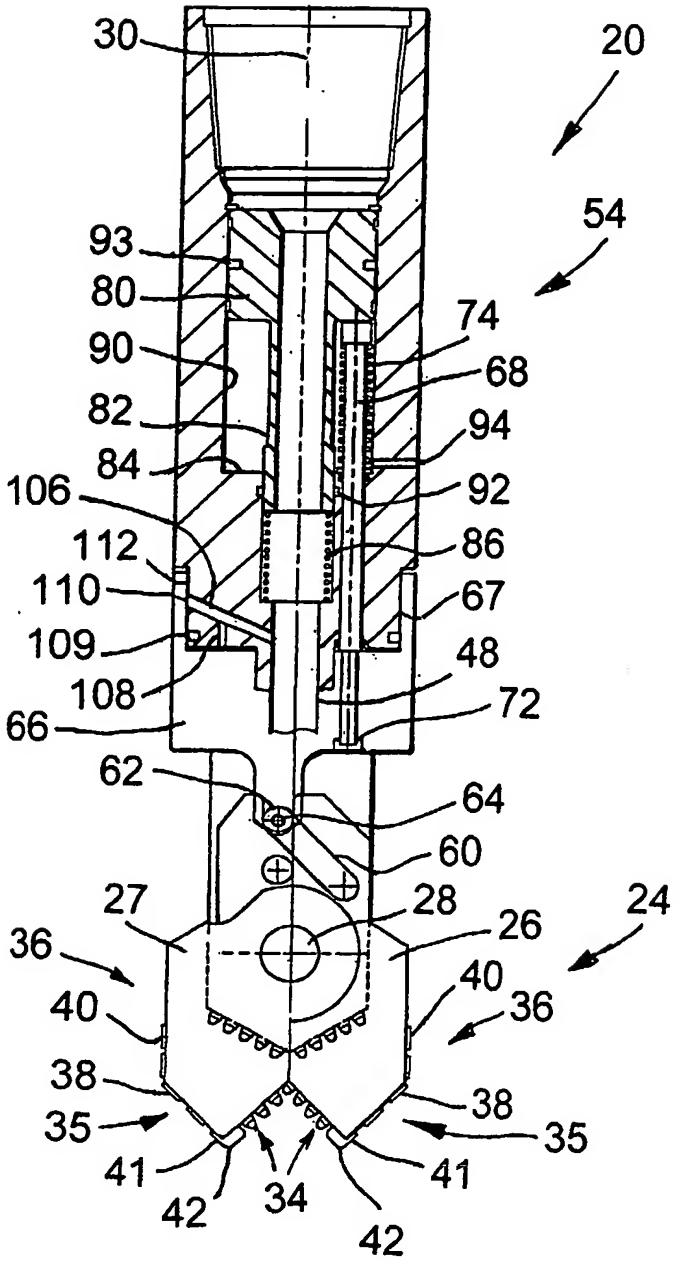
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Fig.3

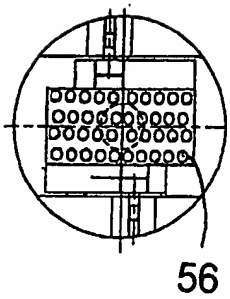
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Fig.4

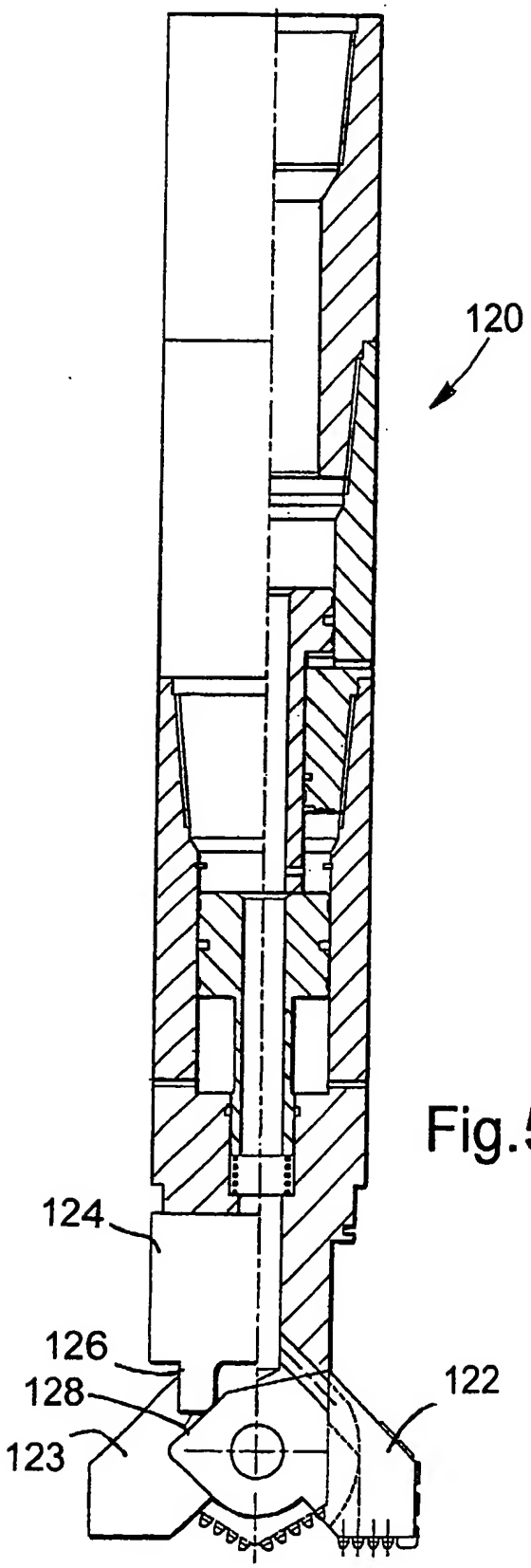

Fig.5

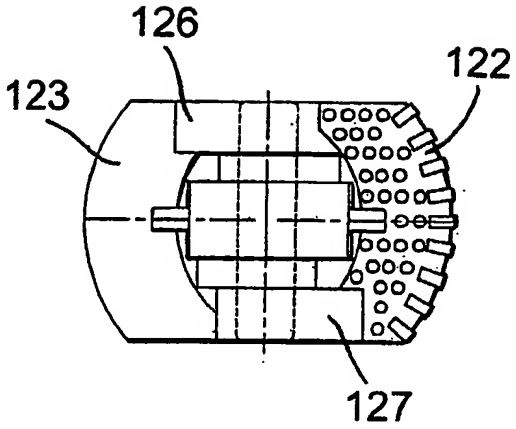

Fig.6

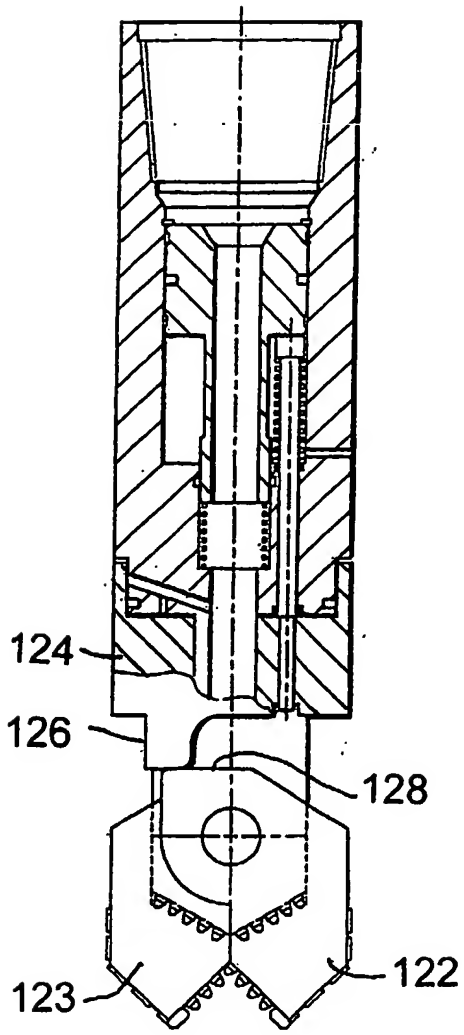

Fig.7

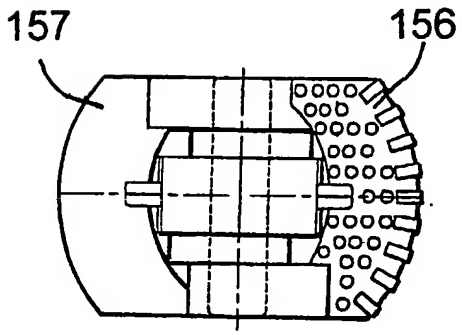

Fig.9

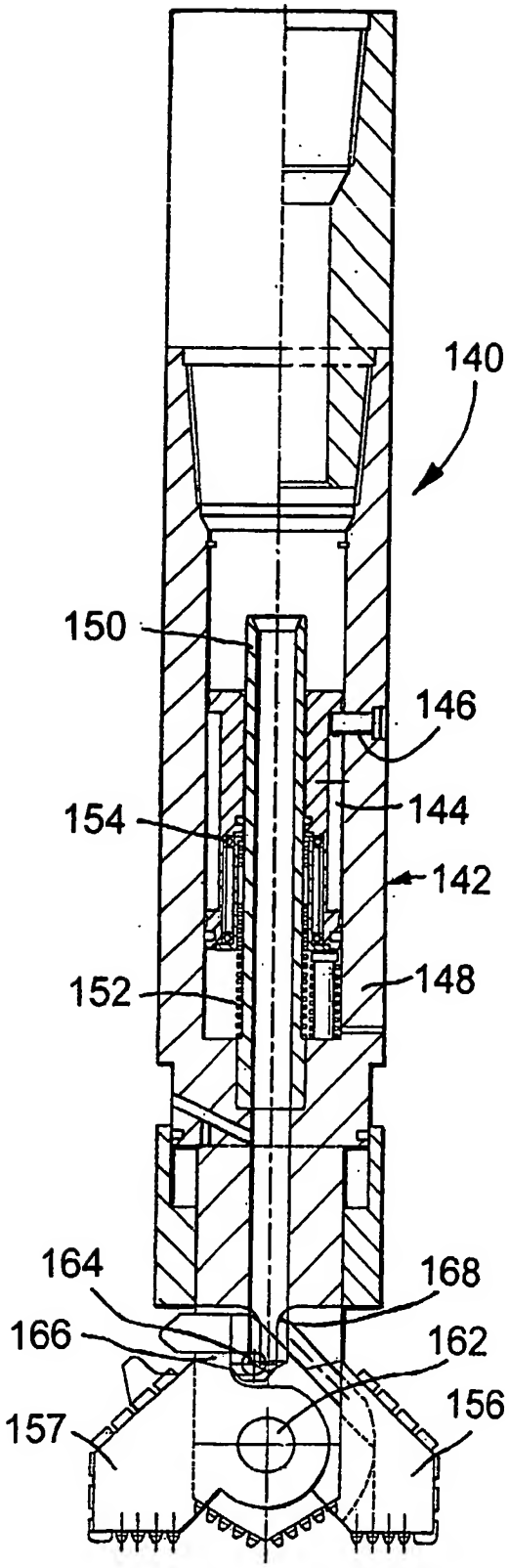

Fig.8

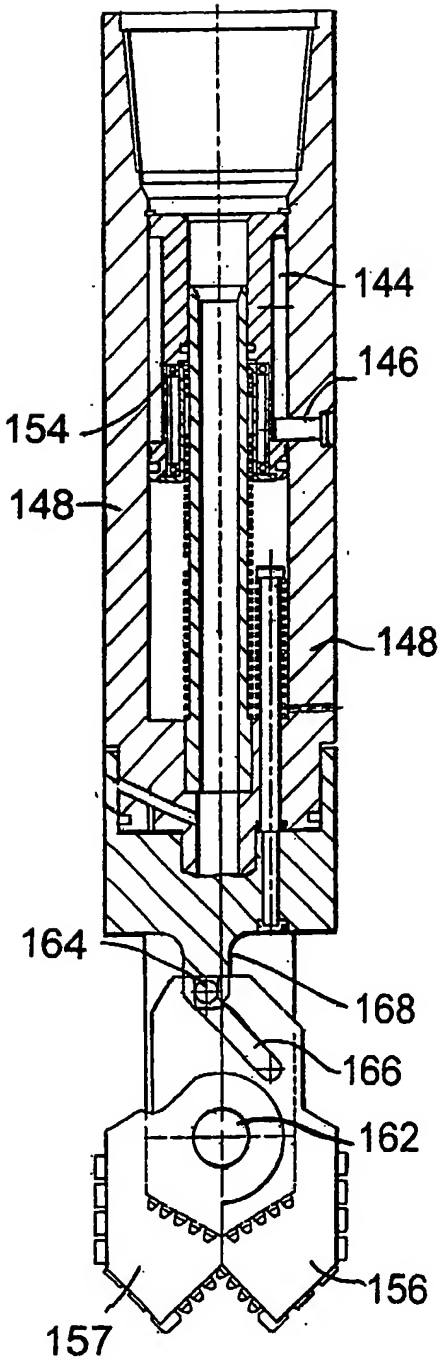

Fig.10

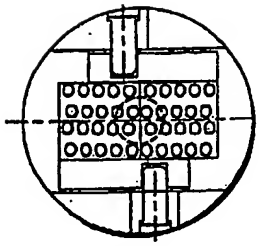

Fig.11

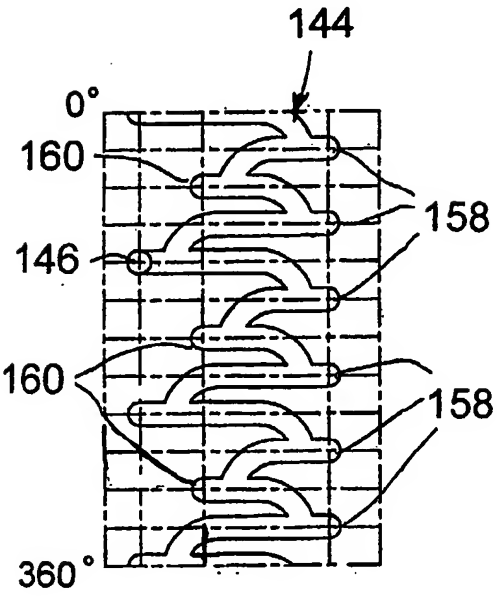

Fig.12

DRILLING APPARATUS

This invention relates to drilling apparatus, and in particular to expandable drilling or reaming apparatus.

GB-A-2 320 270 describes an underreamer with extendable cutting blades. The tool may be run into a bore on a tubular drill string with the blades in a retracted position, that is with the cutting face of each blade extending longitudinally of the tool body. On reaching the cutting location, an increase in fluid pressure within the body induces movement of a piston which acts, via appropriate cam faces, to pivot the blades through 90° to an extended cutting position.

In the retracted position, the blades lie adjacent and overlapping one another, within the circumference of the body. While this provides for a compact "running" arrangement, it limits the available cutting area of the blades and also prevents the blades from cutting while in the retracted position. Further, to permit full extension of the blades it is necessary for parts of the blade cutting faces to pass through a position just prior to the fully extended position, where the effective diameter described by the blades is larger than the bore gauge cut by the blades in the fully extended position. Thus, the blades must cut a profile in the bore wall to permit full

extension. Similarly, on retraction of the blades following reaming of a section of bore, it is necessary for the blades to cut an enlarged diameter profile in the bore to permit blade retraction, or to pull the tool back up to the previously cut profile, before the blades may retract. Clearly, the requirement to cut such a profile is time-consuming and inconvenient, and is also impractical when the underreamer is located, for example, within steel casing.

Due to the 90° rotation of the blades from the retracted position to the extended position, a portion of the cam face on each blade is rotated to a position where the cam face forms a part of the cutting face of the blade, and thus is exposed to an increased risk of wear and damage, which could interfere with the subsequent successful retraction and extension of the blades.

It is among the objectives of embodiments of the present invention to obviate or mitigate these and other disadvantages of this and other prior art arrangements.

According to a first aspect of the present invention, there is provided drilling apparatus comprising:

a body; and

at least two cutting blades pivotally mounted to the body and movable between a retracted position and an extended position, the cutting blades each having a maximum gauge cutting portion, in the extended position the gauge

cutting portions being located in a transverse plane on or forward of the blade pivot axis.

As the maximum gauge cutting portions always lie on or forward of the blade pivot axis, the blades may move between the extended and retracted positions without having to pass through a position where the blades define a diameter larger than the extended blade cutting gauge.

Preferably, the blades are located at or towards the end of the body, such that there is no limit placed on the blade length.

Preferably, the blades are rotatable through an angle of less than 90°, and most preferably are rotatable through an angle of about 45°.

Preferably, cutting portions of each blade extend across the full width of the blade in a direction parallel to the pivot axis or axes of the blades. This allows provision of a relatively large cutting surface, providing enhanced stability and allowing for cutting element redundancy. Most preferably, the maximum gauge cutting portions comprise part-cylindrical cutting areas.

Preferably, the blades are adapted to cut in both the retracted and extended positions. Thus, in the retracted position, the blades define a swept cutting area of larger diameter than the body; drill cuttings may thus pass between the body and the bore wall, avoiding any tendency for the cuttings to jam the apparatus in the bore.

Preferably also, each cutting blade has a retracted position gauge cutting portion. Most preferably, with the blades in the retracted position, these cutting portions define part-cylindrical cutting areas. With the blades in the extended position, these cutting portions may provide cutting areas useful for back-reaming. The retracted position gauge cutting portions also facilitate extension of the blades by allowing the cutting of an increasing diameter bore to accommodate blade extension.

Preferably, the cutting blades each define a cutting portion which, with the blades fully extended, defines a forward facing cutting face. In a preferred embodiment, the cutting faces extend over at least one half or more of the diameter swept by the blades. Most preferably, in the fully extended configuration, these cutting faces lie in a substantially transverse plane. With the blades fully extended, each gauge cutting portion preferably presents a cutting area in an axial plane. Thus, each forward facing cutting portion will lie substantially perpendicular to the respective gauge cutting portion, and preferably the transition between the two portions is provided with cutting elements, most preferably chisel tooth inserts. Preferably also, with the blades in the retracted positions, these cutting portion transitions define the leading edges of the blades. These leading edges are preferably in the form of lines or points and are adapted

to minimise the lateral forces experienced by the blades such that the blades are not urged to expand, and the blade faces may further be adapted to urge the blades to remain in the retracted position. In other embodiments, the gauge hole may be cut by cutting elements provided on both the forward facing cutting portion and the maximum gauge cutting portions.

Preferably, the body has a leading end defining a cutting area, and which may carry cutting elements. Preferably, the cutting area is only exposed when the blades are extended. The cutting area may be utilised when the blades are extended and serve to cut a central area of the bore, the extended blades cutting an annular outer area, and thus the apparatus may be utilised to cut a relatively large diameter bore.

Preferably, the blades are pivotable on a common axis, which may be defined by a common pivot pin, but the blades may alternatively be pivotable on different axes. Most preferably, each blade engages the pivot pin at two locations, spaced along the length of the pin, thus stabilising the blades, and minimising pin and blade wear and loading.

Preferably, in the fully extended position, blade faces are provided to engage the body, the faces acting as stops and serving to transfer forces to the body, thus reducing the stress experienced by the pivot pins. Most

preferably, the faces are formed to allow transfer of both axial and rotational forces.

Preferably, the apparatus includes a blade actuation arrangement. Preferably, the actuation arrangement positively engages each blade, thereby allowing for positive extension and retraction of the blades, and facilitating positive retention of the blades in a desired position, for example allowing application of weight on bit (WOB) in both extended, retracted, and intermediate positions. In a preferred embodiment, each blade defines a cam slot or groove and the actuation arrangement includes a cam follower, which may be in the form of a stud or pin. This allows elimination of blade return torsion springs between the blade and the pivot pin; a blade retraction arrangement may be provided at a more convenient location, for example within the body.

Preferably, the actuation arrangement is fluid pressure responsive, and in a preferred embodiment comprises one or more fluid pressure responsive pistons. Most preferably, the piston is biassed towards a blade retracting position. The movement of the piston may be controlled or limited, for example the piston may be coupled to the body via a cam arrangement. This facilitates positive positioning of the blades in intermediate positions, or permits the apparatus to experience elevated fluid pressure or weight on bit (WOB)

without lateral movement of the blades, for example the actuation arrangement may be held in a retracted position, with the blades in the retracted position, while fluid is circulated through the apparatus to supply ports or jets and the retracted blades are used for drilling. Such a piston may be bearing mounted to the body to facilitate relative rotation. The piston may act on the blades via an axially extending elongate member or rod, preferably via a pair of rods, which may be biassed to a retracted position; where the blade actuation arrangement positively engages the blades, the blades are thus biassed to the retracted position. The rods provide a convenient means of transferring force through the body. The actuation arrangement may comprise an axially movable skirt or sleeve. The skirt may define a piston area which is exposed to internal body fluid pressure, such that an increase in such pressure will tend, initially at least, to extend the skirt, and thus extend the blades.

Most preferably, the actuating piston is annular and defines a throughbore to permit fluid passage therethrough, which fluid may supply jetting nozzles or the like, or act on one or more further actuating pistons.

Preferably, the body defines one or more fluid passages which direct fluid onto or towards the blades. In one embodiment the blades also define fluid passages or channels which co-operate with body passages to carry fluid

towards cutting portions or areas of the blades. The body may include at least one body passage which is only opened when the blades are extended. The resulting pressure drop may serve as an indicator to the operator that the blades have extended. The body may include at least one body passage which directs fluid to an area of the apparatus for cleaning or purging purposes, such that movement of the blades, particularly retraction, is not prevented by, for example, build-up of drill cuttings or other debris between parts of the apparatus.

The cutting portions or areas of the blades and body may be provided with any appropriate cutting elements or surfaces, include tungsten inserts and PDC cutters.

It will be apparent to those of skill in the art that at least some of these preferred features of the first aspect of the invention will have utility in other forms of drilling or reaming apparatus which may form other aspects of the invention.

This and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a part-sectional view of drilling apparatus in accordance with a first aspect of the present invention, shown with the blades of the apparatus in an extended position;

Figure 2 is an end view of the apparatus of Figure 1,

shown with some cutting elements omitted;

Figure 3 is a part-sectional view of the drilling apparatus of Figure 1, shown with the blades in a retracted position;

Figure 4 is an end view of the apparatus of Figure 1, shown with the blades omitted;

Figure 5 is a part-sectional view of drilling apparatus in accordance with a second aspect of the present invention, shown with the blades of the apparatus in an extended position;

Figure 6 is an end view of the apparatus of Figure 5, shown with some cutting elements omitted;

Figure 7 is a part-sectional view of the drilling apparatus of Figure 5, shown with the blades in a retracted position;

Figure 8 is a part-sectional view of drilling apparatus in accordance with a third aspect of the present invention, shown with the blades of the apparatus in an extended position;

Figure 9 is an end view of the apparatus of Figure 8, shown with some cutting elements omitted;

Figure 10 is a part-sectional view of the drilling apparatus of Figure 8, shown with the blades in a retracted position;

Figure 11 is an end view of the apparatus of Figure 8, shown with the blades omitted;

Figure 12 is a view illustrating the cam profile defined by the actuating piston of the apparatus of Figure 8.

Reference is first made to Figures 1, 2, 3 and 4 of the drawings, which illustrate drilling apparatus 20 in accordance with a first embodiment of the present invention.

The apparatus 20 comprises a generally cylindrical tubular body 22 with a rectangular cross-section leading end body portion 24 providing mounting for two cutting blades 26, 27 via a pivot pin 28 which intersects and lies perpendicular to the body axis 30. The body 22 is adapted to be coupled to a saver sub 32 mounted on the leading end of a tubular drill string (not shown).

The blades 26, 27 are pivotable between a retracted position (Figure 3) and an extended position (Figures 1 and 2). Each blade 26, 27 defines three cutting faces 34, 35, 36, each providing mounting for respective cutting elements 38, 39, 40, such as tungsten carbide inserts. The first cutting faces lie perpendicular to the body axis 30 when the blades 26, 27 are extended, and each face 34 defines a relatively large area part-annular cutting face (see Figure 2), providing for cutting element redundancy. The second cutting faces 35 lie perpendicular to the first faces 34 and are part-cylindrical. In the fully extended position, the faces 35 cut the bore gauge. The corner 41 between the

faces 34, 35 is provided with cutting elements in the form of chisel tooth inserts 42. The third cutting faces 36 lie at 45° to the second faces 35 and in the fully extended position provide a cutting face useful for back-reaming.

Each blade 26, 27 defines a passage 44 which, when the blades 26, 27 are fully extended, communicates with a respective outlet 46 of a passage 48 in the body 22. In use, drilling fluid passes through the passages 48, 44 and exits the passes 44 at openings 49 adjacent the first cutting faces 34.

The blades 26, 27 are each mounted on the pivot pin 28 via a pair of spaced arms or lugs 50, 51 and 52, 53 and, as noted above, are pivotable between extended and retracted positions. The blades 26, 27 are fluid actuated under the control of an actuation arrangement 54, as will be described.

In the retracted position, as shown in Figure 3, the blade corners 41 form the leading ends of the apparatus, and the arrangement is such that, while drilling in this configuration, the blades 26, 27 experience minimal lateral forces which would otherwise tend to extend the blades 26, 27. It will also be noted that, in this configuration, the third cutting faces 36 will cut the bore gauge.

With the blades 26, 27 in the extended configuration the apparatus 20 may be utilised for reaming an existing bore to a larger diameter, or for cutting a large diameter

bore. As the extended blades 26, 27 define an annular swept area, the body portion 24 has a chisel end carrying cutting elements 56 which will cut the central bore area.

The blades 26, 27 each define a cam slot 60 which co-operates with a respective cam follower 62 mounted on a respective lug 64 extending from the end of a blade actuating skirt or sleeve 66 mounted on a stepped portion of the body 67. The skirt 66 is coupled to a pair of axially extending rods 68 (only one shown) which pass into the interior of the body 22, each rod 68 being fixed to the skirt 66 by means of an opposing shoulder 70 and a circlip 72. A compression spring 74 is mounted around each rod 68 between a further rod shoulder 76 and a face of the body. The springs 74 tend to retract the rods 68 into the body 22, and thus also tend to retract the skirt 66 and blades 26, 27.

The heads of the rods 68 are engaged by the head of an annular first actuating piston 80 mounted in the body 22, the piston 80 also having a hollow cylindrical extension 82 accommodated by a shouldered body bore portion 84. A compression spring 86 is provided between the bore shoulder 88 and the free end of the piston extension 82 and urges the piston 80 towards a blade retracted position. The head of the piston is movable in a chamber 90 isolated from the body bore by piston seals 92, 93 and the portion of the chamber 90 between the seals 92, 93 is in fluid

communication with the body exterior via body ports 94.

The head of the piston 80 is engaged by the leading end of a second annular actuating piston 96 accommodated in an intensifier sub 98 forming part of the body 22. In a similar manner to the first piston 80, the head of the second piston 96 is movable in a chamber 100 isolated from the body bore by piston seals 102, 103, with the portion of the chamber 100 between the seals 102, 103 being in fluid communication with the body exterior via body ports 104. Both pistons 80, 96 are of one piece construction.

Due to the provision of the annular pistons 80, 96, drilling fluid may pass through the body 22 to the passages 48, 44, and also to passages 106 which direct fluid behind the skirt 66. Each passage 106 has an outlet 108 directing fluid into an area between seals 109 (only one shown) between the skirt and body, such that drilling fluid pressure will tend to move the skirt 66 towards the blade extended position. A further outlet 110 directs fluid into an annular cavity 112 formed between the body and the extended skirt 66, keeping the cavity 112 clear of drill cuttings and thus facilitating retraction of the skirt 66. The outlet 110 is also directed uphole, to facilitate circulation and cuttings entrainment away from the blades 26, 27.

In use, the apparatus 20 may be run into a drilled bore on the end of a drill string, with the blades 26, 27

in the retracted position. If necessary the string may be rotated to assist in dislodging obstructions in the bore. On reaching the end of the bore, the apparatus may be utilised to drill with the blades 26, 27 in a retracted position. However, the primary application of the apparatus 20 is drilling with the blades 26, 27 in the extended position. This is achieved by pumping drilling fluid through the string from surface, the resulting differential pressure between the body bore and the annulus between the body and the bore wall urging the pistons 80, 96 to extend the blades 26, 27 through 45°, in the illustrated example from an initial diameter of 311 mm to an extended diameter of 406 mm. Extension of the blades 26, 27 may be detected at surface by the drilling fluid pressure drop which occurs with the opening of the outlet 110, on extension of the skirt 66.

In the fully extend position, faces machined onto the blade locating arms 50, 53 engage the body extension. The faces serve as stops for the blades 26, 27. Further, the faces allow for transfer of forces directly to the body 22, thus reducing the stress experienced by the pivot pin 28, particularly when the apparatus is subject to weight-on-bit (WOB).

The blade cutting faces 34, 35, 36, and in particular the second and third faces 35, 36, are formed such that the blades 26, 27 may cut as they are extended, the relatively

large area of the faces 35, 36 providing a large cutting area and subsequently a large number of active cutting elements.

Retraction of the blades 26, 27 is achieved simply by reducing the drilling fluid pressure, the various springs and the cam arrangement serving to positively retract the blades 26, 27 in the absence of the differential fluid pressure acting on the pistons 80, 96.

Further, the presence of wiper seals of the rods and skirt, and the purging of the skirt cavity, minimise the likelihood of any jamming or sticking during retraction.

Reference is now made to Figures 5, 6 and 7 of the drawings, which illustrate drilling apparatus 120 in accordance with a further embodiment of the invention. The apparatus 120 shares many features with the apparatus 20 described above, and in the interest of brevity the common features will not be described again.

The primary difference between the two embodiments lies in the coupling between the blades 122, 123 and the actuating skirt 124: the blades 122, 123 are not positively engaged by the skirt 124, rather the skirt 124 includes a pair of lugs 126, 127 which abut cam faces 128 on the respective blade lugs. Due to the requirement of the blades to pivot through only 45°, the faces 128 do not form part of the cutting structure, and thus are unlikely to suffer erosion, and only a relatively short stroke is

required to fully extend the blades, allowing the apparatus length to be kept down.

Reference is now made to Figures 8 to 12 of the drawings, which illustrate drilling apparatus 140 in accordance with a third embodiment of the invention. The apparatus 140 bears many similarities to the apparatus 20 described above, and the common features of the two embodiments will not be described again in any detail.

The primary difference lies in the form of the single actuating piston 142 which, in this embodiment, defines a cam track 144 which co-operates with a cam pin 146 mounted on the body 148. The piston 142 is mounted on an axial sleeve 150 fixed to the body 148, and is biassed towards a retracted position by a compression spring 152 positioned around the sleeve 150. The piston 142 is coupled to the spring 152 via a bearing 154, facilitating rotation of the piston 142 as the pin 146 travels along the track 144.

Figure 12 illustrates the position of the pin 146 in the track 144 when the blades 156, 157 are fully extended, as shown in Figures 8 and 9, in response to the circulation of drilling fluid through the apparatus. In the absence of circulation the blades 156, 157 retract to the position shown in Figure 10, and the pin occupies one of the opposite cam end stops 158.

However, the cam track 144 also defines intermediate stops 160, which allow the blades 156, 157 to be retained

in the retracted position in the presence of circulation or WOB. Thus, this apparatus 140 is suited to the drilling of pilot holes, with the blades 156, 157 held in the retracted position.

In the absence of circulation, the various springs ensure that the blades 156, 157 are or remain retracted.

In the light of greater likelihood of the blade pivot pin 162 experiencing WOB, the pin 162 is strengthened. Also, with the blades 156, 157 retracted, the blade cam pins 164 are located in axial portions of the blade cam slots 166, such that the pins 164 do not experience any axial forces, but do serve to prevent lateral movement of the blades 156, 157. Furthermore, the blade cam pins 164 are "captured" such that the pins 164 are retained and cannot fall out of the skirt lugs 168 in the event that the pins 164 are sheared.

Those of skill in the art will appreciate that these various embodiments of the present invention provide drilling apparatus which overcomes many of the disadvantages of prior proposals. It will also be understood that various modifications and improvements may be made to these embodiments, without departing from the scope of the invention.

CLAIMS

1. Drilling apparatus comprising:

a body; and

at least two cutting blades pivotally mounted to the body and movable between a retracted position and an extended position, the cutting blades each having a maximum gauge cutting portion, in the extended position the gauge cutting portions extending axially and being located in a transverse plane on or forward of the blade pivot axis.

2. The apparatus of claim 1, wherein the blades are located at or towards the end of the body.

3. The apparatus of claim 1 or 2, wherein the blades are rotatable through an angle of less than 90°.

4. The apparatus of claim 3, wherein the blades are rotatable through an angle of about 45°.

5. The apparatus of any of the preceding claims, wherein cutting portions of each blade extend across the full width of the blade in a direction parallel to the pivot axis or axes of the blades.

6. The apparatus of any of the preceding claims, wherein the maximum gauge cutting portions comprise part-cylindrical cutting areas.

7. The apparatus of any of the preceding claims, wherein the blades are adapted to cut in both the retracted and extended positions.

8. The apparatus of claim 7, wherein each cutting blade has a retracted position gauge cutting portion.

9. The apparatus of claim 8, wherein, with the blades in the retracted position, the retracted position gauge cutting portions define part-cylindrical cutting areas.

10. The apparatus of claim 8 or 9, wherein, with the blades in the extended position, the retracted position cutting portions provide cutting areas adapted for back-reaming.

11. The apparatus of claim 8, 9 or 10, wherein the retracted position gauge cutting portions are adapted to facilitate extension of the blades by allowing the cutting of an increasing diameter bore to accommodate blade extension.

12. The apparatus of any of the preceding claims, wherein the cutting blades each define a cutting portion which, with the blades fully extended, defines a forward facing cutting face.

13. The apparatus of claim 12, wherein said cutting faces extend over at least one half or more of the diameter swept by the blades.

14. The apparatus of claim 12 or 13, wherein, in the fully extended configuration, said cutting faces lie in a substantially transverse plane.

15. The apparatus of any of the preceding claims, wherein, with the blades fully extended, each gauge cutting portion presents a cutting area in an axial plane.

16. The apparatus of claim 15, when dependant on claim 12, 13 or 14, wherein each forward facing cutting portion lies substantially perpendicular to the respective gauge cutting portion.

17. The apparatus of claim 16, wherein the transition between each forward facing cutting portion and the respective gauge cutting portion is provided with cutting elements.

18. The apparatus of claim 17, wherein said cutting elements are chisel tooth inserts.

19. The apparatus of claim 17 or 18, wherein, with the blades in the retracted positions, said cutting portion transitions define the leading edges of the blades.

20. The apparatus of any of the preceding claims, wherein the body has a leading end defining a cutting area.

21. The apparatus of claim 20, wherein said cutting area carries cutting elements.

22. The apparatus of claim 20 or 21, wherein said cutting area is only exposed when the blades are extended.

23. The apparatus of any of the preceding claims, wherein the blades are pivotable on a common axis.

24. The apparatus of claim 23, wherein said pivot axis is defined by a common pivot pin.

25. The apparatus of claim 24, wherein each blade engages the pivot pin at two locations, spaced along the length of the pin.

26. The apparatus of claim 24 or 25, wherein, in the fully extended position, blade faces are provided to engage the body, the faces acting as stops and serving to transfer forces to the body.

27. The apparatus of any of the preceding claims, further comprising a blade actuation arrangement.

28. The apparatus of claim 27, wherein the actuation arrangement positively engages each blade.

29. The apparatus of claim 28, wherein each blade defines a cam slot or groove and the actuation arrangement includes a cam follower.

30. The apparatus of claim 27, 28 or 29, wherein the actuation arrangement is fluid pressure responsive, .

31. The apparatus of claim 30, wherein the actuation arrangement comprises one or more fluid pressure responsive pistons.

32. The apparatus of claim 31, wherein the piston is biassed towards a blade retracting position.

33. The apparatus of claim 31 or 32, wherein the piston is

coupled to the body via a cam arrangement.

34. The apparatus of claim 33, wherein the piston is bearing mounted to the body to facilitate relative rotation.

35. The apparatus of any of claims 31 to 34, wherein the piston acts on the blades via an axially extending elongate member.

36. The apparatus of claim 35, wherein the member is biassed to a retracted position.

37. The apparatus of any of claims 31 to 36, wherein the actuating piston is annular and defines a throughbore to permit fluid passage therethrough.

38. The apparatus of any of claims 27 to 37, wherein the actuation arrangement comprises an axially movable skirt.

39. The apparatus of claim 38, wherein the skirt defines a piston area which, in use, is exposed to internal body fluid pressure, such that an increase in such pressure tends to extend the skirt, and thus extend the blades.

40. The apparatus of any of the preceding claims, wherein

the body defines one or more fluid passages which direct fluid onto or towards the blades.

41. The apparatus of claim 40, wherein the blades also define fluid passages or channels which co-operate with said body passages to carry fluid towards cutting portions or areas of the blades.

42. The apparatus of any of the preceding claims, wherein the body includes at least one body passage which is only opened when the blades are extended.

43. The apparatus of any of the preceding claims, wherein the body includes at least one body passage which directs fluid to an area of the apparatus for cleaning or purging purposes.

44. The apparatus of any of the preceding claims, wherein cutting portions or areas of the blades and body are provided with cutting elements.

Amendments to the claims have been filed as follows

1. Drilling apparatus comprising:

a body; and

at least two cutting blades pivotally mounted to the body and movable between a retracted position and an extended position, the cutting blades being adapted to cut in both the retracted and extended positions and each having a retracted position minimum gauge cutting portion and an extended position maximum gauge cutting portion, in the extended position the gauge cutting portions extending axially and intersecting a transverse plane on or forward of the blade pivot axis.

2. The apparatus of claim 1, wherein the blades are located at or towards the end of the body.

3. The apparatus of claim 1 or 2, wherein the blades are rotatable through an angle of less than 90°.

4. The apparatus of claim 3, wherein the blades are rotatable through an angle of about 45°.

5. The apparatus of any of the preceding claims, wherein cutting portions of each blade extend across the full width of the blade in a direction parallel to the pivot axis or axes of the blades.

6. The apparatus of any of the preceding claims, wherein the maximum gauge cutting portions comprise part-cylindrical cutting areas.

7. The apparatus of any of the preceding claims, wherein, with the blades in the retracted position, the retracted position gauge cutting portions define part-cylindrical cutting areas.

8. The apparatus of any of the preceding claims, wherein, with the blades in the extended position, the retracted position cutting portions provide cutting areas adapted for back-reaming.

9. The apparatus of any one of the preceding claims, wherein the retracted position gauge cutting portions are adapted to facilitate extension of the blades by allowing the cutting of an increasing diameter bore to accommodate

blade extension.

10. The apparatus of any of the preceding claims, wherein the cutting blades each define a cutting portion which, with the blades fully extended, defines a forward facing cutting face.

11. The apparatus of claim 10, wherein said cutting faces extend over at least one half or more of the diameter described by the fully extended blades.

12 The apparatus of claim 10 or 11, wherein, in the fully extended configuration, said cutting faces lie in a substantially transverse plane.

13. The apparatus of any of the preceding claims, wherein, with the blades fully extended, each maximum gauge cutting portion presents a circumferentially and axially extending cutting area.

14. The apparatus of claim 13, when dependant on claim 10, 11 or 12, wherein each forward facing cutting portion lies substantially perpendicular to the respective maximum gauge

cutting portion.

15. The apparatus of claim 14, wherein the transition between each forward facing cutting portion and the respective maximum gauge cutting portion is provided with cutting elements.

16. The apparatus of claim 15, wherein said cutting elements are chisel tooth inserts.

17. The apparatus of claim 15 or 16, wherein, with the blades in the retracted positions, said cutting portion transitions define the leading edges of the blades.

18. The apparatus of any of the preceding claims, wherein the body has a leading end defining a cutting area.

19. The apparatus of claim 18, wherein said cutting area carries cutting elements.

20. The apparatus of claim 18 or 19, wherein said cutting area is only exposed when the blades are extended.

21. The apparatus of any of the preceding claims, wherein the blades are pivotable on a common axis.

22. The apparatus of claim 21, wherein said pivot axis is defined by a common pivot pin.

23. The apparatus of claim 22, wherein each blade engages the pivot pin at two locations, spaced along the length of the pin.

24. The apparatus of claim 22 or 23, wherein, in the fully extended position, blade faces are provided to engage the body, the faces acting as stops and serving to transfer forces to the body.

25. The apparatus of any of the preceding claims, further comprising a blade actuation arrangement.

26. The apparatus of claim 25, wherein the actuation arrangement positively engages each blade.

27. The apparatus of claim 26, wherein each blade defines a cam slot or groove and the actuation arrangement includes

a cam follower.

28. The apparatus of claim 25, 26 or 27, wherein the actuation arrangement is fluid pressure responsive.

29. The apparatus of claim 28, wherein the actuation arrangement comprises one or more fluid pressure responsive pistons.

30. The apparatus of claim 29, wherein the piston is biassed towards a blade retracting position.

31. The apparatus of claim 29 or 30, wherein the piston is coupled to the body via a cam arrangement.

32. The apparatus of claim 31, wherein the piston is bearing mounted to the body to facilitate relative rotation.

33. The apparatus of any of claims 29 to 32, wherein the piston acts on the blades via an axially extending elongate member.

34. The apparatus of claim 33, wherein the member is biassed towards a retracted position.

35. The apparatus of any of claims 29 to 34, wherein the actuating piston is annular and defines a throughbore to permit fluid passage therethrough.

36. The apparatus of any of claims 25 to 35, wherein the actuation arrangement comprises an axially movable skirt.

37. The apparatus of claim 36, wherein the skirt defines a piston area which, in use, is exposed to internal body fluid pressure, such that an increase in such pressure tends to extend the skirt, and thus extend the blades.

38. The apparatus of any of the preceding claims, wherein the body defines one or more fluid passages which direct fluid onto or towards the blades.

39. The apparatus of claim 38, wherein the blades also define fluid passages or channels which co-operate with said body passages to carry fluid towards cutting portions or areas of the blades.

40. The apparatus of any of the preceding claims, wherein the body includes at least one body passage which is only opened when the blades are extended.

41. The apparatus of any of the preceding claims, wherein the body includes at least one body passage which directs fluid to an area of the apparatus for cleaning or purging purposes.

42. The apparatus of any of the preceding claims, wherein cutting portions or areas of the blades and body are provided with cutting elements.

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Claims searched:	All	**Date of search:**	5 April 2001

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): E1F FCJ, FFR, FLA

Int Cl (Ed.7): E21B 7/28, 10/32, 29/00

Other: Online: EPODOC, WPI, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, Y	GB2320270A	(PSL) Whole Document	X: 1-6, 12, 13, 20-24, 27 Y: 14-16
Y	GB2211221A	(Hailey) Esp. Abstract.	42
X, Y	GB2172315A	(Luen) Esp. Fig. 1.	X: 1 Y: 14-16, 25-26.
X, Y	GB643197	(Dehn) Esp. Fig. 1.	X: 1, 2 Y: 14-16, 27-28.
X,Y	US5853054	(Smith Int.) Esp. Fig. 1.	X:1, 5 Y: 14-16-42

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